Influence of soil-amino acid interaction and pesticides on physicochemical properties of soil and uptake by plant

SHORT SYNOPSIS

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Certificate

I hereby declare that the short synopsis "**Influence of soil-amino acid interaction and pesticides on physicochemical properties of soil and uptake by plant**" being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Chemistry under FET, of ManavRachna International Institute of Research and Studies, Faridabad during the academic year 2022-2023. It is a bonafide record of original work carried out under the supervision of Dr.ShaguftaJabin that has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that short synopsis is plagiarism free and proof has been submitted.

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ABSTRACT

The wellbeing of human being majorly depends upon ecological factors and environment. Ecological factors depend upon feature of available soil for different purpose in life. Soil is the most important raw material for meeting basic human needs. Soil is an important medium in which plants grow. Soil is of utmost importance for agricultural purposes and living organisms. A good understanding of the physico-chemical properties of different kinds of soil is significant for environmental sustainability. Therefore, the study on physico-chemical properties of soil is of great importance, as both chemical and physical properties affect soil productivity. Thus, physicochemical study of soil includes bulk density, electrical conductivity, available nitrogen, pH, moisture, available nitrogen, soil organic matter, temperature, phosphorus andpotassium. Among all properties, pH is the most important parameter as it affects all other physico-chemical properties of soil. Therefore, understanding the complex relationships among all soil properties is of great importance for the wide application of soil in agriculture.

Modern farming methods are also a major contributor to soil contamination. Today, as agricultural technology advances, large amounts of pesticides, chemical fertilizers as well as soil conditioners are used to increase crop yields. To control pests and pest-borne diseases various types of pesticides are used which put stress on the natural environment. They contaminate root of crops by adsorbing into soil colloids. In addition to pesticides, soil fumigants and conditioners are also applied to increase soil fertility and to kill unwanted insects. The aim of the research is to study how different pesticides, adding to a soil, can change the properties of the soil as well as the interaction of the soil with amino acids. It is also aimed to study the unique property of soil interms of adsorption of pesticides and amino acids with the help of characterization techniques such as X-ray diffraction (XRD) and Scanning electron microscopy (SEM)

Keywords: soil organic matter, Physico-chemical properties, soil amendment, pesticides, Amino acids, Scanning electron microscopy (SEM), X-ray diffraction (XRD)

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1. INTRODUCTION

"Soil" comes from a Latin word, "solum" which means ground (Khanifar et al., 2021). It has a dynamic role in supporting life in the universe. “Soil Chemistry” is an interesting branch from a perspective of research, as on one hand it has a distinctive characteristic of producing and sustaining crops, but on the other hand, there are some soils which may be unable to produce any kind of crop, nevertheless they are soils (Khan et al., 2000; Sparks et al., 2019).

Soil is a complex mixture of water, organic matter, minerals and air. The fractions of soil have a major impact on soil structure, porosity and texture. These properties influence water and air movement in the layer of soil, thereby disturbing the soil's ability to function. As a result, soil physico-chemical properties have a significant impact on soil quality. The texture of the soil, in particular, can have a significant impact on many other properties (Embe and Asriani, 2021). As a result, one of the most important physical properties of soil is its texture. Further, soil texture is a complex fraction made up of different mineral particles such as sand, clay and silt (Tale and Ingole, 2015). The fine mineral fraction is made up of these particles, which may vary in size. However, particle size has an impact on soil physico-chemical properties of soil. Some of the physicochemical properties have been explained below to develop a better understanding of properties and structure of soil. In view of significant relationship attached to amino acids, soil and pesticides, the present study is aimed to investigate the mechanism processes of polar and nonpolar amino acids through soil amended with insecticides and fungicides.

1.1 PHYSICO-CHEMICAL PROPERTIES OF SOIL

The various physical and chemical properties of soil are as follows:

(i) Mechanical composition

Mechanical composition is one of the most important parameter to assess the quality of soil. Mechanical composition explains the varying size of gravel, silt, clay and sand present in soil. The size of gravel, sand and silt are > 2mm, 0.02-2mm, 0.002- 0.02 respectively (Dazhou et al., 2021). The presence of particles of different sizes is responsible for influencing the water holding capacity, which is one of the most important characteristics of soil.

(ii) Electrical conductivity (EC)

Electrical conductivity gives a significant indication about the soluble salt present in soil. The salinity of soil can be calculated by the presence of soluble salt in soil. Electrical conductivity of the water should vary from 0.1-0.75 mmhos cm^{-1} (Park and Smucker 2005; Wang et al 2015). When EC is greater than 4.0 mmhos cm^{-1}, the soil is considered to be saline enough to indicate the existence of NaCl and Na_2SO_4 as soluble salts in soil.

(iii) pH

pH is vital property of soil which gives an idea about alkalinity or acidity of the soil. Soil pH also significantly affects the availability of plant nutrients (Andersson et al 2001). Macronutrients are generally less available to soil at acidic medium. However, micronutrients tend to be more available to the soil at high pH due to the precipitation. Soil microbial population are also influencing soil pH. As per literature, Clay is rich in containing different cations (Kiran et al, 2013). The extent and nature of cations vary from soil to soil and it is reflected from their cation exchange properties (Kekane e al, 2013). Soil rich in aluminium is mostly acidic in nature and pH range varies from 3.8-5.8 (Solanki et al 2012). In addition, soil rich in sodium ions is basic in nature and its pH varies from 8.5- 10.5.

(iv) Exchangeable cations

Exchangable cation are present in agricultural soils as Mg^{2+}, K^+, Ca^{2+}, H^+, Na^+ and NH_4^+ ions. Throughout the process of weathering, water present around the soil is rich in Ca^{2+}, Mg^{2+}, Na^+, K^+ ions (Chantawong et al., 2003). The clay minerals present in soil reacts with cation and get adsorbs on its surface. Generally, Ca^{2+} ions are generally adsorbed to a larger extent as compared to other ions (Schoenholtza et al., 2000). The quantity of exchangeable cation varies with the amount of colloidal content present in soil. Consequently, clay present in soil contain a higher amount of total exchangeable cations than sand (Mobar et al., 2015).

(v) Cation exchange capacity (CEC)

Cation exchange capacity is one of the most crucial properties of soil. It signifies the amount of negative charge which is offered to bring positively charged cations into the solution and strongly influence nutrient availability (Patel et al., 2014; Mebrate et al., 2022). The CEC of soil

varies with the nature and organic matter of the soil (Schoenholtza et al., 2000; Lotse et al., 2022). Soil rich in montmorillonite is having high CEC. However, kaolinite is having low exchange capacity (Shivanna et al., 2014).

(vi) Soil texture

Soil texture is an important tool used to determine the types of soil used in agricultural (Tale, 2015). Soil present in different region is having different texture. In addition, soil texture greatly depends upon different particle size of soil. Soil texture greatly effects aeration in plants (Solanki and Chavda, 2012). Soil texture has direct influence on electrical conductivity also.

(Vii) Soil Temperature

The temperature of soil varies from -20^{o}C to 60^{o}C. The physical, biological and chemical characteristics of soil are influenced by the soil temperature. The microorganisms are biologically active in warm soil rather than in cold soil. The soil surface has a different temperature than that of the inner layer of soil (Onwuka et al., 2018)

1.2. Soil Adsorption

Surface of soil is majorly accountable for different environmental and industrial applications of soil. Soil chemistry has a substantial impact on the function of soil as an adsorbent. Soil colloidal particles have the ability to absorb liquids, even solids and gases on their surface. The application of soil as an adsorbent was studied by soil scientists. Clay minerals are mainly responsible for adsorption which is made up of silica and alumina sheets (Sangiumsak et al 2014). As per literature, the exchangeable ions as well as structure of soil make the surface porous which is used as adsorbents. Scientists explored the adsorptive behaviour of soil in natural as well as in modified forms (Yu et al., 2023). Thus, ion exchange or adsorption properties are the primary criteria for determining soil fertility (Martin et al., 2017). This property allows soil to hold plant nutrients and water, for plant use making them available. It allows soil colloids to act as a nutrient basin for plant use.

2.Litrature Review

Review of literature gives an essential understanding of the methodologies that were used in the past.

2.1 Soil Amendment

The physico-chemical properties of soil get highly influenced by soil amendments (Li et al., 2012; Zhang et al., 2023). It also affects the mobility or interaction of some organic and inorganic matter present in the soil. Soil amendments can be pesticides, polymers, organic acids, fly ash, surfactants, dyes and many more (Rasool et al., 2022; Khan et al., 2023).

2.1.1. Amino Acids

Animal proteins are made up of 20 naturally occurring amino acids. At isoelectric pH, amino acid is mostly dipolar ions in solution known as zwitter ions, these molecules have no net charge. Because an alpha carbon is an asymmetric carbon, every amino acid exists as a two enantiomers. The enantiomers are well known as D-isomers and L-isomers. Amino acids found in existing system are just about L-isomers, except for a few D-isomers (Andersson and Berggren, 2005).

Nitrogen present in soil in both organic and inorganic forms (Sharma et al 2022). Most of the surface soils contain more than 95% nitrogen (Bingham et al., 2016; Jacoby et al 2017). As per literature, 40% of total nitrogen exists in soil in the form of amino acids. These amino acids are present into three categories:

(i) Free amino acids (FRAA): They are available in dissolved form in the soil. They are freely available in plants (Cao et al., 2016).

(ii) Exchangeable amino acids (EXAA): They are bonded together with the charged surfaces on soil organic matter and clay particles of soil (Jones *et al.*, 2002).

(iii) Bound amino acids (BOAA): The large quantities of amino acids are available in bound form in protein and peptides(Hatton et al., 2012).

BOAA are mostly available indirectly to the plants and considered as reservoirs. However, the concentration of FRAA in soil is in the range of 0 to 158 μM. In addition, inorganic nitrogen in soil is the important source of plant-nitrogen and soluble organic-nitrogen in soils.

The FRAA is a significant source of energy for microorganisms present in soil for plant growth, especially when inorganic-nitrogen availability is limited.

Amino acids are synthesized by plants themselves. Photosynthesis is the first step which involves the synthesis of carbon hydrate. It includes the use of oxygen, carbon from air and hydrogen from aqueous medium. In the last step, carbon hydrate interacts with nitrogen, which further results into the formation of amino acid metabolic pathways. The requirement of amino acids in sufficient quantities is required to enhance crop yield and its quality. Apart from self-synthesis, plants also get amino acids directly from the soil which helps plants to get nutrition and hence improve the microflora of soil.

Soil thin layer chromatography (soil-TLC) is best and economical technique used by soil scientists to find out the mobility of amino acids through pure soil as well as with soil amended with pesticides (Dar et al., 2023). The mobility of amino acids through soil bed explains the soil-amino acid interactions simultaneously (Khatri et al., 2020).

Thin layer chromatography (TLC) is an analytical technique used for identifying and monitoring the adsorption behaviour of different kinds of amino acids using soil as a stationary phase modified with various concentrations of different pesticides. The study exploits TLC to determine the mobility of four main uncharged amino acids: alanine, tryptophan glycine and glutamine in terms of retention factor. Glycine has the highest mobility of the four amino acids studied. When pure water was utilized as a mobile phase, the order of mobility was determined to be glycine > alanine > tryptophan > glutamine (Khan et al., 2023).

Table 1: The types and Role of Amino Acids in plants:

Types of Amino acids	**Role of amino acids in plants**	**Molecular weight**
Glycine	Chlorophyll formation is enhanced in its presence and it helps in vegetative growth.	75
Isoleucine	It increases the shoot system,early yield and growth.	131
Methionine	It is present in the cycle of ethylene formation and help in fruit ripening.	149
Phenylalanine	It helps in embryo formation, improving plant cell.	165
Serine	It makes hormonal balance in plant and activating chlorophyll	105
Glutamic acid	It increases the plant growth and increases the yield.	147
Aspartic acid	It enhances resistance to plants from diseases.	133

Alanine	It affects the plant growth velocity, and activating chlorophyll formation.	89
Threonine	It increases plant tolerance to diseases.	119

2.1.2. Pesticides

Pesticides are those substances which are used to prevent, destroy, repel, attract or control pests, including undesirable species of animals and plants during the storage, production,distribution and agricultural modifications (Jaleel and Gopi 2007; Kaur et al 2022). These are the numerous poisonous substances, and they are available in gaseous, liquid, and solid forms. Microbial activity does not alter by pesticides concentration, for soil fertility which is important (Pathak et al.,2022), when applied at recommended rates. Pesticides are mainly classified as: insecticides; herbicides; rodenticides; nematicides, fungicides and so on (Frizzi et al.,2008).

Insecticides: The chemical substances,commonly used for killing insects are known as insecticides. They are sprayed on plants and leaf, eaten by targeted insects. Insecticides kill the insects through their respiratory system and insects vanishes simply by external bodily contact with insecticides (Ismail et al., 2001).

Herbicides: To control unwanted weeds in cultivated crop plants, they are mainly used.Herbicide molecules transform into toxic compounds and stop biological activities. They haveability to penetrate plant tissue and interfere with specific biological or physiological processes in plants.

Fungicides: They are used to control plant pathogens. Fungicides are absorbed by plant tissues and translocated either side from the site of application to control diseases away when applied to various plant parts (Khan and Chaudhary, 2006).

Rodenticides: These are mainly used to kill and controlrats, squirrels, mice, rodents, etc. The common chemicals such as warfarin, sodium fluoroacetate, nor bromide, cyanide,etc.are used as rodenticides. Warfarin acts as an anticoagulant and lowers the level of prothrombin, a blood protein required for blood clotting. Sodium fluoroacetate, a highly toxic rodenticide, causes harmful effects on central nervous system and interferes with heart functions of rodents. Rat's small peripheral blood vessels are constricted by nor-bromide (Hassan and Allah,2005).

Nematicides: They are used to control underground nematodes that attack plant root hairs. The nematode problem affects all crop-growing areas around the world. It is more damaging in "old tired soil," to be precise, soil that has been cultivated for a long time. The use of nematicidal chemicals may reduce crop losses (Kaushik et al., 2006).

3. Research Gap

Pesticides have also been used in earlier times by many researchers in the field of agriculture. It has been successfully applied to amend the properties of the soil in a better way so that yield of the crops is enhanced in one way or the other. Here, the work is majorly limited to insecticide and fungicide and its relationship and interface with soil. So, there is a need to discuss and study the relationship between different types of pesticides along with soil. In order to instil the better understanding of the concepts, variety of crops can be planted in the soil amended with pesticides and to observe its outcome.

4. Assessment of Broader Area

Soil chemistry research is fascinating and necessary for better crop production. In this field of study, soil can be modified by using a diversity approaches to alter its physico-chemical properties in a favourable or unfavourable manner, explains how pesticides such as dimethoate, carbendazim, parathionmethyl, methyldemeton and chloroyrifosendosulfanaffect amino acid mobility via soil TLC. It also discusses how pesticides affect physiological factors such as seed germination, the number of leaves a plant has, the length of its shoots, the length of its roots, the weight of its fresh and dry shoots, and the amount of nutrition a plant that is used contains. The rate at which amino acids move through pesticide-treated soil could be slowed, affecting how plants and crops produce.

5. Objective of the Research:

The objectives of the research are mentioned below:

- To find out the physico-chemical properties of soil collected from various locations of Faridabad district and to assess its characteristics.
- To analyze the changes in physico-chemical properties of soil amended with pesticides such as pH, EC, CEC, mechanical composition, moisture content, etc.

- To study the composition of different soil samples of Faridabad district such as silt, clay and sand.
- To evaluate the complex relationship between the soil and amino acids by using soil-TLC (Thin Layer Chromatography) technique.
- To separate and identify the different fungicides and insecticides in soil by soil thin layer chromatography.
- To assess the effects of insecticide and fungicide in conjunction with amino acids in growth of plant interms of shoot length, shoot weight, growth of root length, overall plant growth as well as the presence of different minerals in fruit and flowers.
- To study the unique property of soil interms of adsorption with the help of characterization techniques such as X-ray diffraction (XRD) and Scanning electron microscopy (SEM).

6. Methodology to be used

The following steps to be followed during research work in order to carry out the proposed research:

- Collection of soil samples from different locations of Faridabad district.
- Sieving of soil to remove any unwanted material from it in the lab.
- To determine the physico-chemical properties of soil samples.
- Amendment of soil with pesticides.
- Use of soil TLC to monitor the mobility of amino acids on the soil.
- Sending the samples prepared for characterization techniques (SEM, XRD) in various research labs.
- Implementation of amended soil to find out its effects on plant growth and crop production.

7. Expected Outcomes of the Research

Adding pesticides to the soil may cause changes in its physicochemical characteristics. The type of soil and pesticides used throughout the investigation would undoubtedly affect the degree of variation. The soil's clay content will have an impact on how the characteristics vary because clay is crucial to the interactions between soil and pesticides. As it is once again impacted by the degree of their interactions, the mobility of polar and non-polar amino acids with pesticides adsorbed soil may or may not follow a regular trend. By employing this type of experimental soil, one can see both favourable and unfavourable effects on plant growth.

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Influence of soil-amino acid interaction and pesticides on physicochemical properties of soil and uptake by plant

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Influence of soil-amino acid interaction and pesticides on physicochemical properties of soil and uptake by plant

SHORT SYNOPSIS

by

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ABSTRACT:

The wellbeing of human being majorly depends upon ecological factors and environment. Ecological factors depend upon feature of available soil for different purpose in life. Soil is the most important raw material for meeting basic human needs. Soil is an important medium in which plants grow. Soil is of utmost importance for agricultural purposes and living organisms. A good understanding of the physico-chemical properties of different kinds of soil is significant for environmental sustainability. Therefore, the study on physico-chemical properties of soil is of great importance, as both chemical and physical properties affect soil productivity. Thus, physicochemical study of soil includes bulk density, electrical conductivity, available nitrogen, pH, moisture, available nitrogen, soil organic matter, temperature, phosphorus andpotassium. Among all properties, pH is the most important parameter as it affects all other physico-chemical properties of soil. Therefore, understanding the complex relationships among all soil properties is of great importance for the wide application of soil in agriculture.

1. INTRODUCTION:

"Soil" comes from a Latin word, "solum" which means ground (Khanifar, 2021). It has a dynamic role in supporting life in the universe. "Soil Chemistry" is an interesting branch from a perspective of research, as on one hand it has a distinctive characteristic of producing and sustaining crops, but on the other hand, there are some soils which may be unable to produce any kind of crop, nevertheless they are soils (Khan et al 2000; Sparks et al 2020).

Soil is a complex mixture of water, organic matter, minerals and air. The fractions of soil have a major impact on soil structure, porosity and texture. These properties influence water and air movement in the layer of soil, thereby disturbing the soil's ability to function. As a result, soil physico-chemical properties have a significant impact on soil quality. The texture of the soil, in particular, can have a significant impact on many other properties (Embe and Asriani, 2021). As a result, one of the most important physical properties of soil is its texture. Further, soil texture is a complex fraction made up of different mineral particles such as sand, clay and silt (Smita et al 2015). The fine mineral fraction is made up of these particles, which vary in size. However, particle size has an impact on soil physico-chemical properties of soil. Some of the physicochemical properties have been explained below to develop a better understanding of properties and structure of soil. In view of significant relationship attached to amino acids , soil and pesticides, the present study is aimed to investigate the mechanism processes of polar and non polar amino acids through soil amended with insecticides and fungicides.

1.1 PHYSICO-CHEMICAL PROPERTIES OF SOIL:

The various physical and chemical properties of soil are as follows:

(i) Mechanical composition:

Mechanical composition is one of the most important parameter to assess the quality of soil. Mechanical composition explains the varying size of gravel, silt, clay and sand present in soil. The size of gravel, sand and silt are > 2mm, 0.02-2mm, 0.002- 0.02 respectively ((Dazhou, 2021). The presence of particles of different sizes is responsible for influencing the water holding capacity, which is one of the various characteristics of soil.

Modern farming methods are also a major contributor to soil contamination. Today, as agricultural technology advances, large amounts of pesticides, chemical fertilizers as well as soil conditioners are used to increase crop yields. To control pests and pest-borne diseases various types of pesticides are used whichput stress on the natural environment. They contaminate root of crops by adsorbing into soil colloids. In addition to pesticides, soil fumigants and conditioners are also applied to increase soil fertility and to kill unwanted insects. The aim of the research is to study how different pesticides, adding to a soil, can change the properties of the soil as well as the interaction of the soil with amino acids. It is also aimed to study the unique property of soil interms of adsorption of pesticides and amino acids with the help of characterization techniques such as X-ray diffraction (XRD) and Scanning electron microscopy (SEM)

Keywords: soil organic matter, Physico-chemical properties, soil amendment, pesticides, Amino acids, Scanning electron microscopy (SEM), X-ray diffraction (XRD)

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